US009228316B2

(12) United States Patent
Staade et al.

(10) Patent No.: US 9,228,316 B2
(45) Date of Patent: Jan. 5, 2016

(54) **MOTOR GRADER CIRCLE DRIVE ASSEMBLY**

(71) Applicant: **Deere & Company**, Moline, IL (US)

(72) Inventors: **Dustin T. Staade**, Dubuque, IA (US); **Nathan J. Horstman**, Durango, IA (US)

(73) Assignee: **DEERE & COMPANY**, Moline, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 251 days.

(21) Appl. No.: **13/788,262**

(22) Filed: **Mar. 7, 2013**

(65) **Prior Publication Data**

US 2014/0251648 A1 Sep. 11, 2014

(51) **Int. Cl.**
E02F 3/84 (2006.01)
E02F 3/76 (2006.01)

(52) **U.S. Cl.**
CPC ***E02F 3/844*** (2013.01); ***E02F 3/764*** (2013.01); ***E02F 3/7654*** (2013.01); ***E02F 3/7668*** (2013.01)

(58) **Field of Classification Search**
CPC E02F 3/764; E02F 3/7668
USPC 172/792, 796
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,844,058	A	*	2/1932	Dean	172/796
2,928,381	A	*	3/1960	MacDonald	91/186
3,028,699	A	*	4/1962	Greeley	172/796
3,712,384	A	*	1/1973	Fisher	172/796
3,721,303	A	*	3/1973	Hanser	172/792
3,924,689	A	*	12/1975	Manor	172/799
3,989,112	A	*	11/1976	Cole et al.	172/796
4,161,987	A	*	7/1979	Tolmer	172/791
4,340,119	A	*	7/1982	MacDonald	172/789
6,129,156	A	*	10/2000	Boast et al.	172/4.5
6,758,286	B2		7/2004	Walker	

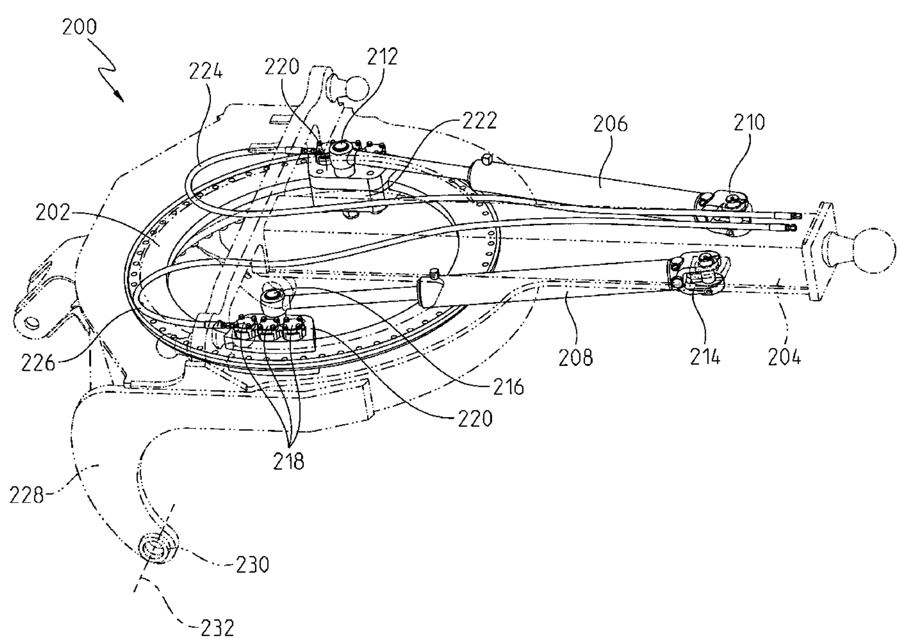
* cited by examiner

Primary Examiner — Thomas B Will
Assistant Examiner — Joel F. Mitchell

(57) **ABSTRACT**

The present disclosure provides a circle drive assembly for a motor grader. The circle drive assembly includes a circle member being rotatable about a rotation axis, a first hydraulic cylinder and a second hydraulic cylinder for rotatably driving the circle member, and a first and second coupling mechanisms. The first hydraulic cylinder has a first end coupled to the first coupling mechanism and the second hydraulic has a second end coupled to the second coupling mechanism. The first coupling mechanism and second coupling mechanism can be controllably moved between a clamped position and an unclamped position. The first hydraulic cylinder rotatably drives the circle member when the first coupling mechanism is in the clamped position and the second hydraulic cylinder rotatably drives the circle member when the second coupling mechanism is in the clamped position.

18 Claims, 4 Drawing Sheets



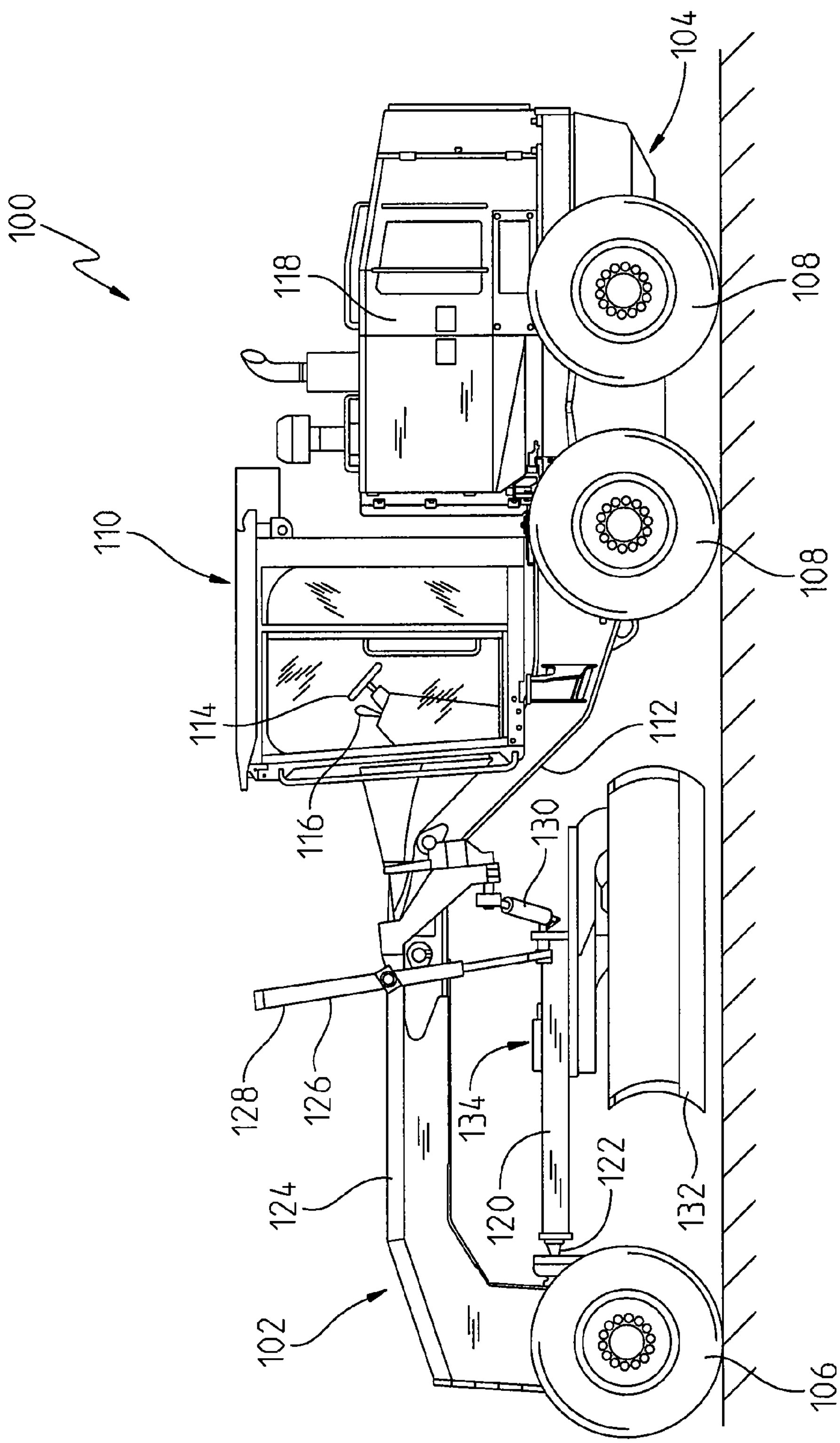


Fig. 1
(Prior Art)

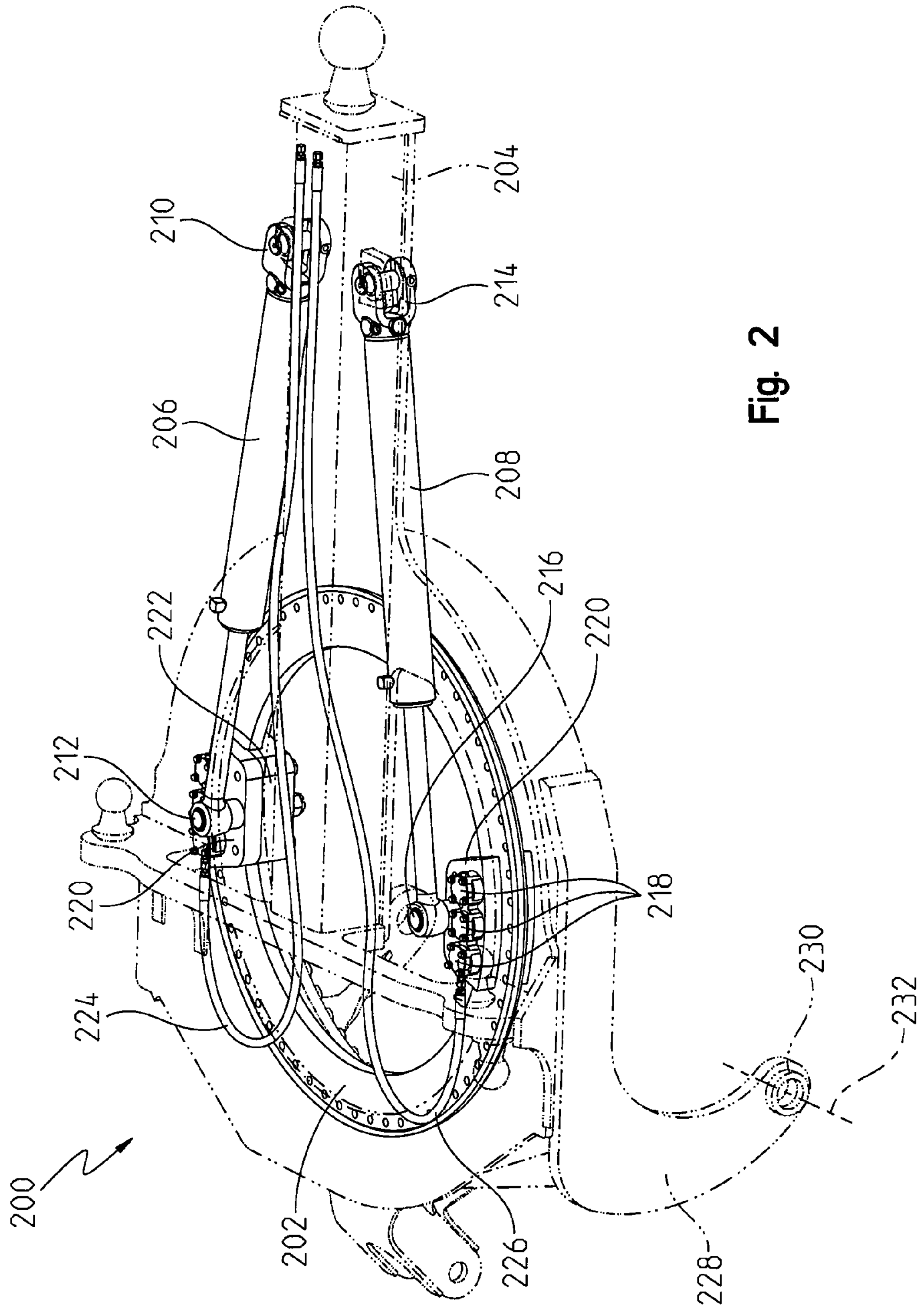

204
210
214
206
208
222
216
220
212
220
218
224
230
232
200
202
226
228

Fig. 2

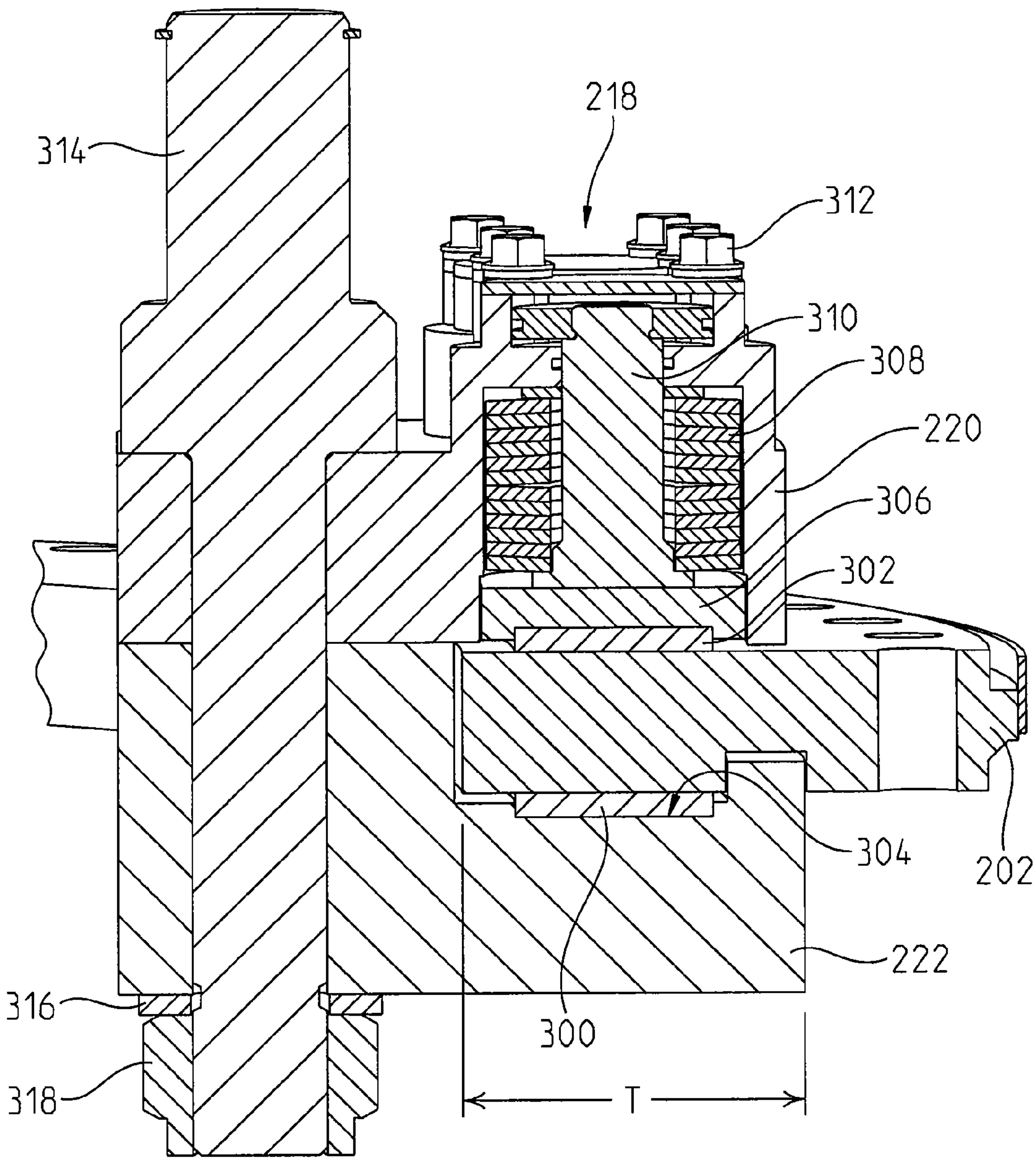


Fig. 3

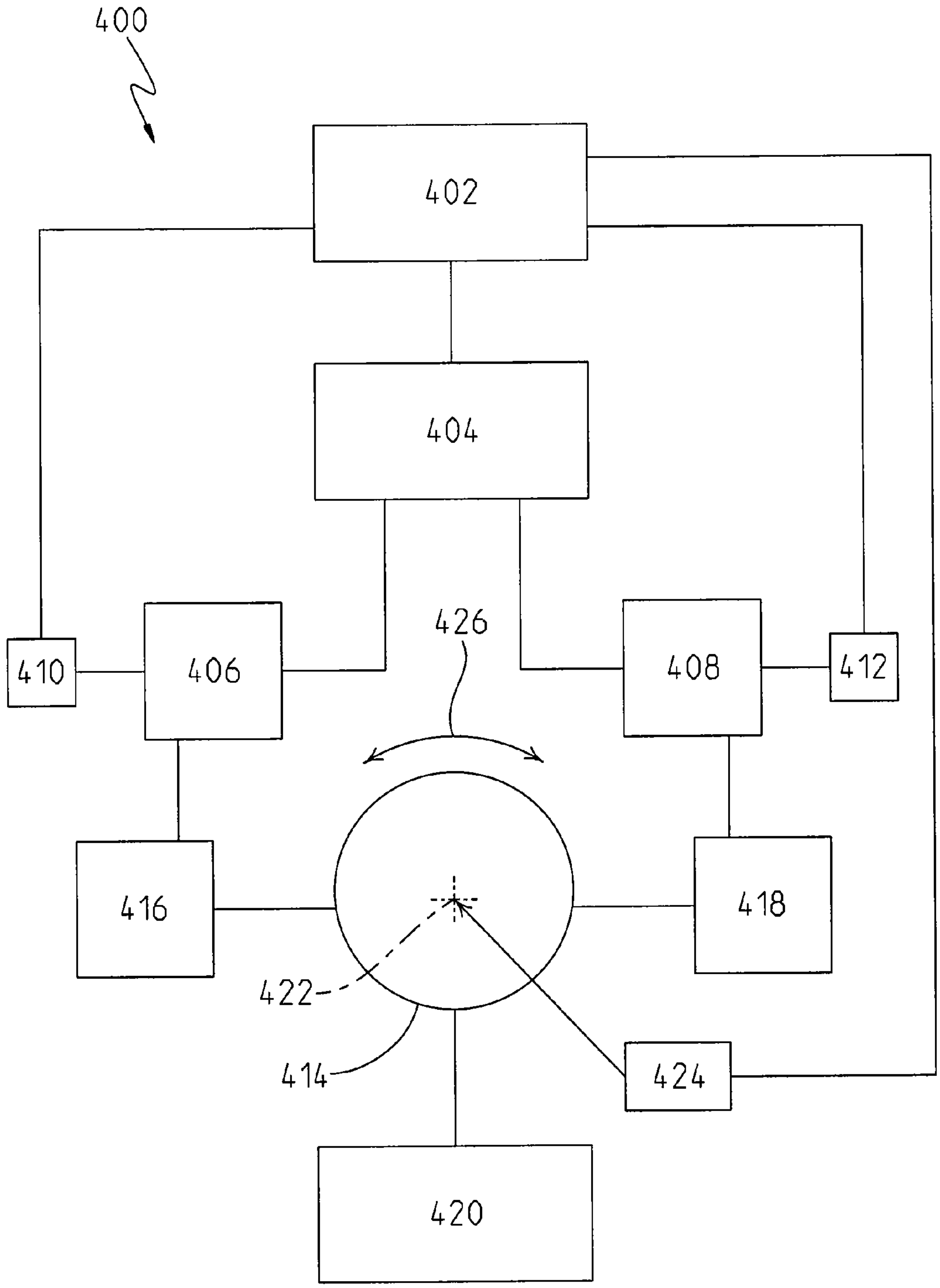


Fig. 4

MOTOR GRADER CIRCLE DRIVE ASSEMBLY

FIELD OF THE DISCLOSURE

The present disclosure relates to a motor grader, and in particular to a circle drive assembly of a motor grader.

BACKGROUND OF THE DISCLOSURE

Work vehicles, such as a motor grader, can be used in construction and maintenance for creating a flat surface. When paving a road, a motor grader can be used to prepare a base foundation to create a wide flat surface for asphalt to be placed on. A motor grader can include two or more axles, with an engine and cab disposed above the axles at the rear end of the vehicle and another axle disposed at the front end of the vehicle. A blade is attached to the vehicle between the front axle and rear axle.

Motorgraders include a drawbar assembly attached near the nose of the grader which is pulled by the grader as it moves forward. The drawbar rotatably supports a circle drive member at a free end of the drawbar and the circle drive member supports a work implement such as the blade. The angle of the work implement beneath the drawbar can be adjusted by the rotation of the circle drive member relative to the drawbar assembly.

In some conventional motorgraders, the circle drive members are supported by a series of bearings attached to the drawbar and the circle drive member includes a series of gear teeth disposed to the exterior circle member or disposed to the interior of the circle member. These gear teeth cooperate with one or more drive gears associated with drive motors attached to the drawbar. In other conventional motorgraders, a worm driven gear box can be mounted to a draft frame of the grader and which rotates pinion gears which mesh with the large ring gear of the circle drive member.

In conventional motor graders, the use of a gear box has limitations. For instance, the gear box can be inefficient and thereby limiting the amount of available power to the drive the work implement. Some alternative solutions have incorporated a hydraulic cylinder, which is more efficient than the gear box. The use of multiple hydraulic cylinders, however, has limitations as well since the cylinders can only rotate the circle so far before the cylinders either crossover one another or cannot continue rotation. Occasionally, the cylinders are not operating in optimal positions and thus need to be repositioned during operation to achieve their full mechanical advantage over the conventional gear box arrangement.

Therefore, a need exists for a circle drive assembly of a motor grader to be driven by hydraulic cylinders. In addition, a need exists for the capability of repositioning the hydraulic cylinders to achieve the full 360° rotation of the circle drive assembly.

SUMMARY

In an exemplary embodiment of the present disclosure, a circle drive assembly is provided for a motor grader. The circle drive assembly includes a circle member being rotatable about a rotation axis, a first hydraulic cylinder and a second hydraulic cylinder for rotatably driving the circle member, and first and second coupling mechanisms. The first hydraulic cylinder has a first end coupled to the first coupling mechanism and the second hydraulic has a second end coupled to the second coupling mechanism. The first coupling mechanism and second coupling mechanism can be controllably moved between a coupled position and an uncoupled position. The first hydraulic cylinder rotatably drives the circle member when the first coupling mechanism is in the coupled position and the second hydraulic cylinder rotatably drives the circle member when the second coupling mechanism is in the coupled position.

In one aspect, each of the first coupling mechanism and second coupling mechanism comprises a plurality of calipers. In another aspect, each coupling mechanism is hydraulically controlled between the coupled and uncoupled positions. In a different aspect, the first end and second end move relative to the circle member in the uncoupled position. In a further aspect, the first end and second end are structured to move in a substantially circular manner relative to the rotation axis as the first and second hydraulic cylinders are actuated. Moreover, the first end is structured to be moved relative to the circle member from a first location to a second location along the circumference of the circle member when the first coupling mechanism is in the uncoupled position and the second end is structured to be moved relative to the circle member from a first location to a second location along the circumference of the circle member when the second coupling mechanism is in the uncoupled position.

In a related aspect, the circle member is structured to be rotatably driven in a clockwise or counterclockwise direction. In addition, each coupling mechanism comprises a first structure and a second structure coupled to one another, the first structure being disposed at least partially above the circle member and the second structure being disposed at least partially beneath the circle member, where the circle member includes a first raised portion that is accommodated within a recess defined in the second structure when the coupling mechanism is in at least the clamped position.

In another embodiment, a motor grader includes a frame for supporting a plurality of wheels, a work implement supported by the frame and adapted to perform a desired operation, a controller, and a circle drive assembly for controlling the work implement. The circle drive assembly includes a circle member being rotatable about a rotation axis, a first hydraulic cylinder and a second hydraulic cylinder for rotatably driving the circle member. The first hydraulic cylinder has a first end coupled to the frame and a second end opposite the first end. The second hydraulic cylinder has a first end coupled to the frame and a second end opposite the first end. A first coupling mechanism is coupled to the second end of the first hydraulic cylinder, where the first coupling mechanism is controllably actuated between an engaged position and a disengaged position. A second coupling mechanism is coupled to the second end of the second hydraulic cylinder, where the second coupling mechanism is controllably actuated between an engaged position and a disengaged position. The first hydraulic cylinder rotatably drives the circle member when the first coupling mechanism is in the engaged position and the second hydraulic cylinder rotatably drives the circle member when the second coupling mechanism is in the engaged position.

In one aspect, a rotation sensor is electrically coupled to the controller such that the rotation sensor is adapted to detect rotational movement of the circle member. A first position sensor and a second position sensor are electrically coupled to the controller. The first position sensor is adapted to detect a stroke length and position of the first hydraulic cylinder and the second position sensor is adapted to detect a stroke length and position of the second hydraulic cylinder. The controller is structured to receive electrical signals from the rotation

sensor, first position sensor, and second position sensor, and based on said signals, actuate one or both of the first and second coupling mechanisms.

In another aspect, the second ends of the first and second hydraulic cylinders move relative to the circle member in the disengaged position. In a different aspect, the first end and second end are structured to move in a substantially circular manner relative to the rotation axis as the first and second hydraulic cylinders are actuated. In a further aspect, each of the first coupling mechanism and second coupling mechanism comprises a plurality of calipers.

In one form of this embodiment, the second end of the first hydraulic cylinder is structured to be moved relative to the circle member from a first location to a second location along the circumference of the circle member when the first coupling mechanism is in the disengaged position and the second end of the second hydraulic cylinder is structured to be moved relative to the circle member from a first location to a second location along the circumference of the circle member when the second coupling mechanism is in the disengaged position. In another form thereof, the circle member is structured to be rotatably driven 360° in a clockwise or counterclockwise direction. In a different form, each coupling mechanism comprises a first structure and a second structure coupled to one another, the first structure being disposed at least partially above the circle member and the second structure being disposed at least partially beneath the circle member, where the circle member includes a first raised portion that is accommodated within a recess defined in the second structure when the coupling mechanism is in at least the engaged position.

In a different embodiment, a method is provided for operably controlling a circle drive assembly of a motor grader. The circle drive assembly includes a circle member rotatable about a rotation axis, a first hydraulic cylinder having a first end, a second hydraulic cylinder having a second end, a first coupling mechanism coupled to the first end, a second coupling mechanism coupled to the second end, a rotation sensor, a first position sensor, and a second position sensor. The method includes detecting a position of the circle member with the rotation sensor, detecting a stroke length of the first hydraulic cylinder and the second hydraulic cylinder with the first position sensor and the second position sensor, sending electrical signals to a vehicle controller based on the detected position of the circle member and stroke lengths of the first hydraulic cylinder and second hydraulic cylinder, coupling the first coupling mechanism to the circle member, actuating the first hydraulic cylinder to change its stroke length, and rotatably moving the circle member about the rotation axis.

In one aspect, the method includes receiving an electrical signal from the vehicle controller, coupling the first coupling mechanism and the second coupling mechanism to the circle member, and rotatably moving the circle member about the rotation axis by the first hydraulic cylinder and the second hydraulic cylinder. In another aspect, the method includes receiving an electrical signal from the vehicle controller, decoupling the first coupling mechanism from the circle member, and moving the decoupled first coupling mechanism from a first location to a second location along the circumference of the circle member such that the decoupled first coupling mechanism moves relative to the circle member. In a different aspect, the method includes (a) coupling the first coupling mechanism and second coupling mechanism to the circle member, (b) rotating the circle member about the rotation axis a distance less than 360°, (c) decoupling at least one of the first and second coupling mechanisms from the circle member, (d) repositioning the at least one decoupled coupling mechanism about the circumference of the circle member, and (e) repeating steps (a)-(d) one or more times to rotatably move the circle member 360° about the rotation axis in a clockwise or counterclockwise direction.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned aspects of the present disclosure and the manner of obtaining them will become more apparent and the disclosure itself will be better understood by reference to the following description of the embodiments of the disclosure, taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a side view of a motor grader;

FIG. **2** is a perspective view of an exemplary circle drive assembly of a motor grader;

FIG. **3** is a partial cross-sectional view of the exemplary circle drive assembly of FIG. **2**; and

FIG. **4** is a schematic of a control system of an exemplary motor grader.

Corresponding reference numerals are used to indicate corresponding parts throughout the several views.

DETAILED DESCRIPTION

The embodiments of the present disclosure described below are not intended to be exhaustive or to limit the disclosure to the precise forms in the following detailed description. Rather, the embodiments are chosen and described so that others skilled in the art may appreciate and understand the principles and practices of the present disclosure.

Referring to FIG. **1**, an exemplary embodiment of a machine, such as a motor grader **100**, is shown. An example of a motor grader is the 772G Motor Grader manufactured and sold by Deere & Company. As shown in FIG. **1**, the motor grader **100** includes front and rear frames **102** and **104**, respectively, with the front frame **102** being supported on a pair of front wheels **106**, and with the rear frame **104** being supported on right and left tandem sets of rear wheels **108**. An operator cab **110** is mounted on an upwardly and forwardly inclined rear region **112** of the front frame **102** and contains various controls for the motor grader **100** disposed so as to be within the reach of a seated or standing operator. In one aspect, these controls may include a steering wheel **114** and a lever assembly **116**. An engine **118** is mounted on the rear frame **104** and supplies power for all driven components of the motor grader **100**. The engine **118**, for example, can be configured to drive a transmission (not shown), which is coupled for driving the rear wheels **108** at various selected speeds and either in forward or reverse modes. A hydrostatic front wheel assist transmission (not shown) may be selectively engaged to power the front wheels **106**, in a manner known in the art.

Mounted to a front location of the front frame **102** is a drawbar or draft frame **120**, having a forward end universally connected to the front frame **102** by a ball and socket arrangement **122** and having opposite right and left rear regions suspended from an elevated central section **124** of the front frame **102** by right and left lift linkage arrangements including right and left extensible and retractable hydraulic actuators **126** and **128**, respectively. A side shift linkage arrangement is coupled between the elevated frame section **124** and a rear location of the drawbar **120** and includes an extensible and retractable side swing hydraulic actuator **130**. A blade **132** is coupled to the front frame **102** and powered by a circle drive assembly **134**.

Referring to FIG. **2**, an exemplary embodiment of a circle drive assembly **200** for a motor grader is shown. The circle drive assembly **200** can include a rotatable circle member **202** coupled to a draft frame **204** or drawbar assembly. The circle member **202** can be rotatable about a rotation axis in a clockwise or counterclockwise direction. The draft frame **204** can include a substantially C-shaped frame member or structure **228**. The substantially C-shaped frame member or structure **228** can define a pivot axis **232**. A tilt frame or other frame element (not shown) can be coupled to the substantially C-shaped frame member or structure **228** at a connection point **230** to allow a motor grader operator to pitch a work implement forwards and backwards. Alternatively, the work implement (e.g., blade) may be directly coupled to the substantially C-shaped member or structure **228**.

The circle member **202** can be rotationally-driven by a first hydraulic cylinder **206** and a second hydraulic cylinder **208**. The first hydraulic cylinder **206** can be coupled or mounted to the draft frame **204** at a first location **210**. The second hydraulic cylinder **208** can be coupled or mounted to the draft frame **204** at a second location **214**. Although not shown in FIG. **2**, the circle member **202** can be rotationally driven about a rotation axis. In this embodiment, the first location **210** and second location **214** can be disposed substantially equidistant from the rotation axis.

The first hydraulic cylinder **206** can be coupled to the circle member **202** at a third location **212** and the second hydraulic cylinder **208** can be coupled to the circle member **202** at a fourth location. The first location **210** and second location **214** are fixedly coupled to the draft frame **204**, whereas the third location **212** and fourth location **216** are movable with respect to the first and second hydraulic cylinders, respectively. Regardless of the position of either hydraulic cylinder, however, the third location **212** and the fourth location **216** are radially spaced from the rotation axis. In other words, the first hydraulic cylinder **206** and second hydraulic cylinder **208** are coupled to the circle member **202** and are substantially equidistantly spaced from the rotation axis (not shown) by the defined radius of the circle member.

Due to the mounting of both hydraulic cylinders to the draft frame **204**, the circle member **202** can rotate a limited angular distance before the rods of each hydraulic cylinder begin to interfere or contact one another. Here, if the first hydraulic cylinder **206** is disposed on a first side and the second hydraulic cylinder **208** is disposed on a second side, the control and performance of the circle drive assembly **200** may be best achieved when the third location or connection point **212** is disposed on the first side of the circle member **202** and the fourth location or connection point **216** is disposed on the second side thereof. In any event, it is desirable for the first hydraulic cylinder **206** and second hydraulic cylinder **208** not to interfere or cross over one another during operation.

To achieve desired performance, the first and second hydraulic cylinders can be coupled to a first structure **220** that is disposed at least partially above the circle member **202**. In other words, the first hydraulic cylinder **206** couples to the circle member **202** at the third location or connection point **212** that is disposed above the circle member **202**. Similarly, the second hydraulic cylinder **208** couples to the circle member **202** at the fourth location or connection point **216** that is disposed above the circle member **202**. In addition, a second structure **222** can be disposed at least partially beneath the circle member **202**. A plurality of coupling mechanisms **218** can be structurally disposed within the first structure **220** and second structure **222**. The plurality of coupling mechanisms **218** can be operably controlled to induce a coupling movement of the first and second structures against the circle member **202**. In one non-limiting example, the plurality of coupling mechanisms **218** can be operably similar to brake calipers. In FIG. **2**, a first fluid line **224** can hydraulically actuate the plurality of coupling mechanisms **218** disposed on the first side of the circle drive assembly **200** as the first hydraulic actuator **206**. Likewise, a second fluid line **226** can hydraulically actuate the plurality of coupling mechanisms **218** disposed on the second side of the circle drive assembly **200** as the second hydraulic actuator **208**. The first fluid line **224** and second fluid line **226** can be coupled to a vehicle controller or control valve to actuate the plurality of coupling mechanisms **218**.

Turning to FIG. **3**, the plurality of coupling mechanisms **218** is shown in greater detail. The first structure **220** and second structure **222** can each include defined openings through which a first fitting **314** and a second fitting **318** can be coupled to one another. A third fitting **316**, such as a washer, may be disposed between the first fitting **314** and second fitting **318**. The first fitting **314** may comprise a bolt or screw, for example, and the second fitting **318** may comprise a nut. Alternatively, these fittings may comprise any known fitting.

As shown, the circle member **202** can be at least partially surrounded by the first structure **220** and second structure **222**. More specifically, a radial thickness T of the circle member **202** can be disposed in contact with either or both the first structure **220** and second structure **222**. To accommodate the coupling of the circle member **202** with the first structure **220** and second structure **222**, the circle member **202** can include a first raised surface **300** and a second raised surface **302**. The first raised surface **300** can be disposed on the opposite side of the circle member **202** from the second raised surface **302**. In FIG. **3**, for example, the second raised surface **302** is disposed slightly above the top surface of the circle member **202**. Similarly, the first raised surface **300** is disposed slightly below the bottom surface of the circle member **202**.

The second structure **222** can include a defined recess **304** formed in an upper portion thereof. The first raised surface **300** of the circle member **202** can be disposed in the defined recess **304** of the second structure **222**. Moreover, the first structure **220** can include a defined cavity (not shown in detail) in which the plurality of coupling mechanisms **218** is at least partially contained. The second raised surface **302** can protrude into the defined cavity as shown in FIG. **3**. In an alternative aspect, the circle member **202** may include a defined recess in its upper and lower surfaces and the first structure **220** and second structure **222** may include raised surfaces that are receivably engaged with the corresponding recesses in the circle member **202**. In a further aspect, the circle member **202** may include a defined recess in one of the upper or lower surfaces and a raised portion in the opposite surface. Corresponding structure may be included in the first structure **220** and second structure **222** to facilitate the coupling of the circle member **202** to both the first structure **220** and second structure **222**. Other aspects for coupling the circle member **202** to both structures may be possible as known to the skilled artisan.

The plurality of coupling mechanisms **218** can be coupled to the first structure **220** by multiple fasteners **312**. The multiple fasteners **312** may be fastened to corresponding openings defined in the first structure **220**. Each of the plurality of coupling mechanisms **218** can include a rod member **310**, a spring **308** and an apply member **306**. When actuated, the rod member **310** can apply a force to the apply member **306** to substantially clamp or couple the first structure **220**, second structure **222**, and circle member **202** together. When clamped or coupled to one another, the first structure **220**, second structure **222**, and circle member **202** can be rotationally driven in unison with one another. However, when the circle member **202** is not clamped or coupled to the first structure **220** and second structure **222**, the first structure **220** and second structure **222** can move relative to the circle member **202**. This can allow the first hydraulic cylinder **206** and second hydraulic cylinder **208**, for example, to be decoupled from the circle member **202** and repositioned without moving the circle member **202**.

The above-description is related to a single aspect for coupling or coupling the circle member **202** to the first structure **220** and second structure **222**. The plurality of coupling mechanisms **218** can be hydraulically actuated. Alternatively, however, the plurality of coupling mechanisms **218** may be electrically actuated, pneumatically actuated, mechanically actuated, electro-mechanically actuated, or actuated in any other known manner. In some aspects, the circle member **202** is clamped by the first and second structures. In other aspects, the circle member **202** may be mechanically coupled via a press-fit engagement, a latch, ratchet, gear mechanism, screw, pin-and-slot configuration, tongue-and-groove configuration, or other means to the first and second structures. It is shown in at least FIG. **2** that the circle member **202** can be rotationally driven by two hydraulic actuators. However, this is only an illustrative embodiment and is not intended to limit the scope of this disclosure. Instead, the circle drive **202** can be rotationally driven by any number of hydraulic cylinders based on size and need. Moreover, it is possible a mechanical actuator or other mechanism can rotationally drive the circle member **202** rather than a hydraulic cylinder.

With reference to FIG. **4**, a control system **400** is provided for controlling an exemplary circle drive assembly. The control system **400** can include a machine or vehicle controller **402**. The circle drive assembly can include a circle member **414** that is similar to the circle member **202** shown in FIGS. **2** and **3**. The circle member **414** can be rotated about a rotation axis **422** in a clockwise or counterclockwise direction **426**. The circle member **414** can change the pitch angle of a work implement **420** such as a blade.

The circle member **414** can be rotationally driven by a first hydraulic cylinder **406** and a second hydraulic cylinder **408**. In other aspect, there may be three or more cylinders for rotationally driving the circle member **414**. The first hydraulic cylinder **406** and second hydraulic cylinder **408** can be disposed in fluid communication with a control valve **404**. In one aspect, the control valve **404** can receive fluid from a hydraulic pump (not shown) that is driven by an engine (not shown), and the control valve **404** can transfer fluid to actuate one or both of the hydraulic cylinders.

The first hydraulic cylinder **406** can be coupled to the circle member **414** via a first coupling mechanism **416**. Similarly, the second hydraulic cylinder **408** can be coupled to the circle member **414** via a second coupling mechanism **418**. The first coupling mechanism **416** and second coupling mechanism **418** can each include a plurality of coupling mechanisms. As the first coupling mechanism **416** and second coupling mechanism **418** are removably coupled, clamped, connected, attached, or otherwise engaged to the circle member **414**, further actuation of one or both of the hydraulic cylinders can rotationally drive the circle member **414** about the rotation axis **422** in either a clockwise or counterclockwise direction **426**.

When the coupling mechanisms are released from the circle member **414**, the circle member **414** is not rotationally driven. Instead, each or both of the first hydraulic cylinder **406** and second hydraulic cylinder **408** can be disengaged from the circle member **414**, repositioned to a more desirable position, and then reengaged to the circle member **414** to further rotationally drive and operate the circle drive assembly. This can allow the repositioning of the hydraulic cylinders to provide or achieve better performance from the machine.

To control the positioning of each hydraulic cylinder, a sensing mechanism or rotation sensor **424** can be provided to detect rotational movement of the circle member **414**. The sensing mechanism or rotation sensor **424** may comprise one or more switches that detect movement, speed, or position of the circle member **414**. The rotational sensor **424** can be electrically coupled to the controller **402** and be in communication or contact with the rotation axis **422** (or the circle member **414** relative to the rotation axis **422**). For instance, an armature (not shown) may be in contact with the circle member **414**. Alternatively, the sensor **424** may encode the circle member **414** similar to a wheel sensor or crankshaft position sensor and communication position information to the controller **402**.

Moreover, a first position sensor **410** can be provided to detect the relative position of the first hydraulic cylinder **406** (e.g., its stroke length). A second position sensor **412** can be provided to detect the relative position of the second hydraulic cylinder **408**. The first position sensor **410** and second position sensor **412** can be electrically coupled to the controller **402** to communicate the stroke length or position of each cylinder. In turn, the controller **402** can have a memory unit that stores readable instructions including logic. The controller **402** can adjustably control the control valve **204** to control each hydraulic cylinder. The controller **402** may also be electrically coupled to the first coupling mechanism **416** and second coupling mechanism **418** to induce an engaging or release of the cylinders and circle member **414**. In this manner, the controller **402** can control the positioning of the hydraulic cylinders based on feedback signals from the rotation sensor **424**, first position sensor **410** and second position sensor **418**. In other embodiments, there may be additional hydraulic cylinders with a position sensor for each cylinder.

As the controller **402** receives signals from the rotation sensor **424**, the first position sensor **410**, and second position sensor **412**, it can control the engagement and disengagement of the coupling mechanisms. Moreover, in doing so, the hydraulic cylinders can be repositioned along the circle member **414** to allow the circle member **414** to be rotated 360° or less. Without the controllable engagement and disengagement of the coupling mechanisms, the hydraulic cylinders would not be able to be repositioned thereby limiting the rotation of the circle member (and, ultimately reducing the amount of torque produced by the circle drive assembly). Instead, the coupling mechanisms can be automatically controlled by the controller **402**, or a machine operator or technician can manually disengage and reposition the cylinders. Moreover, the coupling mechanisms may couple to the circle member in accordance with any coupling means and is not limited to a coupling movement.

In an alternative aspect, the control system **400** of FIG. **4** may not include a sensing mechanism or rotation sensor **424**. Instead, the controller **402** may only receive feedback signals from one or both positions sensors **410**, **412**. Based on these signals, the controller can control rotational movement of the circle member **414** based on the measured stroke length of each hydraulic cylinder.

In yet another alternative aspect, the control system **400** may not include the position sensors **410**, **412**. As such, a direct measurement of cylinder rod stroke length may not be known. In one instance, a sensor or other detecting mechanism may be configured to detect or measure the angular positions of the first coupling mechanism **416** and second coupling mechanism **418** relative to the draft frame. In other words, the controller **402** may interpret a defined or threshold angular position, e.g., 0° or 90°, to indicate that the corresponding hydraulic cylinder is at its maximum stroke length, or that for purposes of controlling the movement of the circle member **414** the cylinder rod is at its longest stroke length relative to the draft frame. This may also be the case for any position of either coupling mechanism along the circle member.

Thus, as the cylinder rod stroke length changes and the coupling mechanism moves about the circle member **414**, the angular position of the coupling mechanism relative to the defined or threshold angular position changes, and based on the newly detected or measured angular position, the controller **402** may determine an estimated stroke length of the hydraulic cylinder.

Referring to FIG. **2**, for example, a sensor or the like may detect that the first hydraulic actuator **206** and second hydraulic actuator **208** are angularly disposed at 45° relative to the draft frame **204**. Based on the known length of each cylinder rod of the first hydraulic actuator **206** and second hydraulic actuator **208**, the known diameter of the circle member **202**, the positioning of the first location **210** and second location **214** relative to the circle member **202**, and the detected angles, the controller **402** of FIG. **4** can detect or estimate the stroke length of each hydraulic actuator or cylinder.

In a further instance, a pressure sensing mechanism or device for each hydraulic cylinder can be in electrical communication with the controller **402**. In this instance, the controller **402** can interpret or determine when one of the hydraulic cylinders reaches its maximum stroke length based on a pressure spike sensed by the pressure sensing mechanism or device. Here, as the hydraulic cylinder reaches its maximum stroke length and any additional pressure command results in a pressure spike, the controller can interpret or detect that the corresponding hydraulic cylinder is at its maximum stroke length. Other known methods and sensing mechanisms may be incorporated into the control system **400** of FIG. **4** for determining cylinder rod stroke length, position of the circle member relative to the rotation axis, or both.

While exemplary embodiments incorporating the principles of the present disclosure have been described hereinabove, the present disclosure is not limited to the described embodiments. Instead, this application is intended to cover any variations, uses, or adaptations of the disclosure using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this disclosure pertains and which fall within the limits of the appended claims.

The invention claimed is:

1. A circle drive assembly for a motor grader, comprising:
- a circle member being rotatable about a rotation axis, the circle member adapted to adjustably control a work implement;
- a first hydraulic cylinder for rotatably driving the circle member, the first hydraulic cylinder having a first end;
- a second hydraulic cylinder for rotatably driving the circle member, the second hydraulic cylinder having a second end;
- a first coupling mechanism coupled to the first end of the first hydraulic cylinder, where the first coupling mechanism is controllably moved between a coupled position and an uncoupled position, the first end coupled to the circle member via the first coupling mechanism when the first coupling mechanism is in the coupled position, the first end uncoupled from the circle member and moveable relative to the circle member when the first coupling mechanism is in the uncoupled position; and

- a second coupling mechanism coupled to the second end of the second hydraulic cylinder, where the second coupling mechanism is controllably moved between a coupled position and an uncoupled position, the second end coupled to the circle member via the second coupling mechanism when the second coupling mechanism is in the coupled position, the second end uncoupled from the circle member and moveable relative to the circle member when the second coupling mechanism is in the uncoupled position;
- wherein the first hydraulic cylinder rotatably drives the circle member when the first coupling mechanism is in the coupled position and the second hydraulic cylinder rotatably drives the circle member when the second coupling mechanism is in the coupled position.

2. The circle drive assembly of claim **1**, wherein each of the first coupling mechanism and second coupling mechanism comprises a plurality of calipers.

3. The circle drive assembly of claim **1**, wherein each coupling mechanism is hydraulically controlled between the coupled and uncoupled positions.

4. The circle drive assembly of claim **1**, wherein the first end and second end are structured to move in a circular manner relative to the rotation axis as the first and second hydraulic cylinders are actuated.

5. The circle drive assembly of claim **1**, wherein:
- the first end is structured to move relative to the circle member from a first location to a second location along a circumference of the circle member when the first coupling mechanism is in the uncoupled position; and
- the second end is structured to move relative to the circle member from a third location to a fourth location along the circumference of the circle member when the second coupling mechanism is in the uncoupled position.

6. The circle drive assembly of claim **1**, wherein the circle member is structured to be rotatably driven in a clockwise or counterclockwise direction.

7. The circle drive assembly of claim **1**, wherein the first coupling mechanism comprises a first structure and a second structure coupled to one another, the first structure being disposed at least partially above the circle member and the second structure being disposed at least partially beneath the circle member, where the circle member includes a first raised portion that is accommodated within a recess defined in the second structure when the first coupling mechanism is in at least the coupled position.

8. A motor grader, comprising:
- a frame for supporting a plurality of wheels;
- a work implement supported by the frame and adapted to perform a desired operation;
- a controller;
- a circle drive assembly for controlling the work implement, the circle drive assembly including:
  - a circle member being rotatable about a rotation axis;
  - a first hydraulic cylinder for rotatably driving the circle member, the first hydraulic cylinder having a first end coupled to the frame and a second end opposite the first end;
  - a second hydraulic cylinder for rotatably driving the circle member, the second hydraulic cylinder having a first end coupled to the frame and a second end opposite the first end;
  - a first coupling mechanism coupled to the second end of the first hydraulic cylinder, the first coupling mechanism controllably actuated between an engaged position and a disengaged position, the second end of the first hydraulic cylinder engaged with the circle mem-

ber via the first coupling mechanism when the first coupling mechanism is in the engaged position, the second end of the first hydraulic cylinder disengaged from the circle member and moveable relative to the circle member when the first coupling mechanism is in the disengaged position; and

a second coupling mechanism coupled to the second end of the second hydraulic cylinder, the second coupling mechanism controllably actuated between an engaged position and a disengaged position, the second end of the second hydraulic cylinder engaged with the circle member via the second coupling mechanism when the second coupling mechanism is in the engaged position, the second end of the second hydraulic cylinder disengaged from the circle member and moveable relative to the circle member when the second coupling mechanism is in the disengaged position;

wherein, the first hydraulic cylinder rotatably drives the circle member when the first coupling mechanism is in the engaged position and the second hydraulic cylinder rotatably drives the circle member when the second coupling mechanism is in the engaged position.

9. The motor grader of claim **8**, further comprising:

a sensing mechanism electrically coupled to the controller, the sensing mechanism adapted to detect rotational movement of the circle member;

a first position sensor electrically coupled to the controller, the first position sensor adapted to detect a stroke length and position of the first hydraulic cylinder; and

a second position sensor electrically coupled to the controller, the second position sensor adapted to detect a stroke length and position of the second hydraulic cylinder;

wherein, the controller is structured to receive electrical signals from the sensing mechanism, first position sensor, and second position sensor, and based on said signals, actuate one or both of the first and second coupling mechanisms.

10. The motor grader of claim **8**, wherein the second end of the first hydraulic cylinder is structured to move in a circular manner relative to the rotation axis as the first hydraulic cylinder is actuated and the second end of the second hydraulic cylinder is structured to move in a circular manner relative to the rotation axis as the second hydraulic cylinder is actuated.

11. The motor grader of claim **8**, wherein each of the first coupling mechanism and second coupling mechanism comprises a plurality of calipers.

12. The motor grader of claim **8**, wherein:

the second end of the first hydraulic cylinder is structured to be moved relative to the circle member from a first location to a second location along a circumference of the circle member when the first coupling mechanism is in the disengaged position; and

the second end of the second hydraulic cylinder is structured to be moved relative to the circle member from a third location to a fourth location along the circumference of the circle member when the second coupling mechanism is in the disengaged position.

13. The motor grader of claim **8**, wherein the first coupling mechanism comprises a first structure and a second structure coupled to one another, the first structure being disposed at least partially above the circle member and the second structure being disposed at least partially beneath the circle member, where the circle member includes a first raised portion that is accommodated within a recess defined in the second structure when the first coupling mechanism is in at least the engaged position.

14. A method for operably controlling a circle drive assembly coupled to a frame of a motor grader, the circle drive assembly being coupled to a frame of the motor grader and including a circle member rotatable about a rotation axis, a first hydraulic cylinder having a first end, a second hydraulic cylinder having a second end, a first coupling mechanism coupled to the first end, a second coupling mechanism coupled to the second end, and a sensing mechanism, the method comprising:

detecting a position of the circle member relative to the rotation axis, a stroke length of the first hydraulic cylinder, or a stroke length of the second hydraulic cylinder with a sensing mechanism;

communicating an electrical signal to a vehicle controller based on the detected position of the circle member or stroke length of either hydraulic cylinder;

coupling at least one of the first coupling mechanism and second coupling mechanism to the circle member;

actuating at least one of the first hydraulic cylinder and second hydraulic cylinder to rotatably drive the circle member about the rotation axis;

uncoupling at least one of the first coupling mechanism and second coupling mechanism from the circle member; and

moving at least one of (i) the first end relative to the circle member when the first coupling mechanism is uncoupled and (ii) the second end relative to the circle member when the second coupling mechanism is uncoupled.

15. The method of claim **14**:

wherein the detecting step further comprises:

detecting the position of the circle member relative to the rotation axis with a rotation sensor;

detecting the stroke length of the first hydraulic cylinder with a first position sensor; and

detecting the stroke length of the second hydraulic cylinder with a second position sensor;

further wherein:

if either the first coupling mechanism or the second coupling mechanism is in a desired position, the first coupling mechanism or second coupling mechanism is coupled to the circle member at the desired position; and

if either the first coupling mechanism or the second coupling mechanism is in an undesired position, the first coupling mechanism or second coupling mechanism is moved from the undesired position to the desired position and then coupled to the circle member at the desired position.

16. The method of claim **14**, further comprising:

receiving an electrical signal from the vehicle controller;

coupling the first coupling mechanism and the second coupling mechanism to the circle member; and

rotatably moving the circle member about the rotation axis by the first hydraulic cylinder and the second hydraulic cylinder.

17. The method of claim **14**, further comprising:

receiving an electrical signal from the vehicle controller;

uncoupling the first coupling mechanism from the circle member; and

moving the uncoupled first coupling mechanism from a first location to a second location along the circle member;

wherein, the uncoupled first coupling mechanism moves relative to the circle member.

18. The method of claim 14, further comprising:

(a) coupling the first coupling mechanism and second coupling mechanism to the circle member;

(b) rotating the circle member about the rotation axis an angular distance less than 360';

(c) uncoupling at least one of the first and second coupling mechanisms from the circle member;

(d) repositioning the at least one uncoupled coupling mechanism about the circle member; and

(e) repeating steps (a)-(d) one or more times to rotatably move the circle member about the rotation axis in a clockwise or counterclockwise direction.

* * * * *